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In re Patent Application of: John E. Donohue
Title: DIGITAL RETURN PATH FOR HYBRID FIBER/COAX NETWORK
Attorney Docket No.: 500.722US1

PATENT APPLICATION TRANSMITTAL

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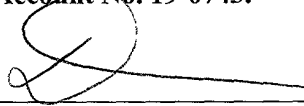
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UNITED STATES PATENT APPLICATION

Digital Return Path for Hybrid Fiber/Coax Network

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Digital Return Path for Hybrid Fiber/Coax Network

Cross Reference to Related Applications

This application is related to the following commonly assigned, co-pending
5 applications:

U.S. Application Serial No. 09/273,197, entitled "DIGITAL RETURN PATH
FOR HYBRID FIBER/COAX NETWORK" and filed on March 19, 1999 (Attorney
Docket No. 500.714US1) (the "714 Application"), and

U.S. Application Serial No. _____, filed on the same date as the present
10 application and entitled "DIGITAL NODE FOR HYBRID FIBER/COAX NETWORK"
(Attorney Docket No. 500.731US1) (the "731 Application").

The 714 Application and the 731 Application are incorporated by reference.

Technical Field of the Invention

15 The present invention relates generally to the field of telecommunications and,
in particular, to a digital return path for a hybrid fiber/coax network.

Background

Cable networks originally carried programming from a head end to subscribers
20 over a network of coaxial cable. Over time, these networks have changed. Some cable
networks now include fiber optic links as part of the network. This variety of cable
network is colloquially referred to as a "hybrid fiber/coax" (HFC) network.

A hybrid fiber/coax network typically includes a head end that broadcasts
programming over the network to subscribers in a downstream direction. The network
25 includes two main portions. The first portion of the network is optical links that
connect the head end with a number of geographically dispersed distribution nodes.
These nodes are referred to as "optical distribution nodes" or "ODNs." At the ODNs,
signals from the head end that carry the programming are converted from optical signals
to electrical signals. The second portion of the network is coaxial links that connect the

ODNs with subscriber equipment. The electrical signals are transmitted to the subscriber equipment over the coaxial cable links.

In recent years, the cable industry has experimented with systems that allow for bi-directional communication between subscriber equipment and the head end. This
5 allows for services such as video-on-demand, telephony and Internet traffic to be offered over a cable network. Typically the 5 to 42 MHZ frequency range is reserved for upstream transmission from customers to the head end. Frequencies between 50 MHZ and an upper limit, e.g., 750 MHZ or 850 MHZ, typically carry downstream transmissions.

10 The design of the reverse path for transporting data over a hybrid fiber/coax network is laced with difficult technical issues. First, many customers must communicate over a common coaxial cable. Interference between customers and noise ingress onto the cable can cause disruptions and errors in this communication. Ingress and other interference is especially a problem at the low frequencies typically prescribed
15 for upstream communications. Transporting simultaneous data transmissions from many customers also introduces complexity into the system design.

In most current systems, the reverse path is implemented with one of a number of different analog modulation schemes, e.g., MCNS, Data Over Cable Service Interface Specification (DOCSIS). These schemes are complicated to implement due to strict
20 timing requirements and complex modulation schemes. Other systems, such as AT&T's mini fiber node (mFNs), introduce other complexities into the return path.

For the reasons stated above, and for other reasons stated below which will become apparent to those skilled in the art upon reading and understanding the present specification, there is a need in the art for an improved return path for a hybrid
25 fiber/coax network.

Summary

The above mentioned problems with telecommunications systems and other problems are addressed by the present invention and will be understood by reading and studying the following specification. A hybrid fiber/coax network is described which includes an optical distribution node that combines CSMA/CD error detection through frequency translation (“frequency turn-around”) with data concentration. In another embodiment, a hybrid fiber/coax network is described which includes a digital return path that transmits upstream, digital data from modems to a head end using modulated carriers that reside, at least in part, below the conventional downstream frequency band, e.g., below 42 MHz. Problems with contention for bandwidth and ingress noise in this frequency spectrum are addressed through a collision detection mechanism that monitors transmissions on the coaxial cable links of the HFC network.

In one embodiment, an optical distribution node for an hybrid fiber/coax network is provided. The optical distribution node includes a laser transmitter coupleable to a fiber optic link that transmits upstream, digital data to a head end of the network. The node also includes a data concentrator coupled to provide the upstream, digital data to the laser. For at least one coaxial cable link of the network coupleable to the optical distribution node, the node also includes a frequency translator that receives the upstream, digital data modulated on a first carrier frequency and retransmits the upstream, digital data to the plurality of modems for collision detection. The node also includes a data interface coupled between the at least one coaxial cable link and the data concentrator that determines whether the upstream data is valid.

Brief Description of the Drawings

Figure 1 is a block diagram of an embodiment of a hybrid fiber/coax network constructed according to the teachings of the present invention.

Figure 2 is a dataflow diagram that illustrates an embodiment of a layered implementation of communication protocol stacks for an optical distribution node according to the teachings of the present invention.

Detailed Description

The following detailed description refers to the accompanying drawings which form a part of the specification. The drawings show, and the detailed description describes, by way of illustration specific illustrative embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be used and logical, mechanical and electrical changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense.

Figure 1 is a block diagram of an embodiment of a hybrid fiber/coax network, indicated generally at 100, and constructed according to the teachings of the present invention. Network 100 is a bi-directional network that carries signals between head end or hub 102 and a number of modems 103-1-1, . . . , 103-M-N. Advantageously, the return path of network 100 is constructed so as to carry the data in digital format, e.g., as Ethernet or other packets of digital data using Internet Protocol (IP), from modems 103-1-1, . . . , 103-M-N to head end 102, thus providing an all digital return path.

Head end 102 is coupled to modems 103-1-1, . . . , 103-M-N over a combination of fiber optics and coaxial cable. Namely, head end 102 is coupled via fiber optic link 105 with optical distribution node 106. Optical distribution node 106 is also coupled to coaxial cable links or branches 108-1, . . . , 108-M. Modems, represented by modems 103-1-1, . . . , 103-M-N, are selectively coupled to coaxial links 108-1, . . . , 108-M via directional couplers 110.

Network 100 includes downstream and upstream (return) paths each of which is described in turn.

In the downstream path, network 100 combines signals from one or more sources at combiner 112 of head end 102. In one embodiment, combiner 112 receives analog and digital video signals. In another embodiment, combiner 112 also receives other data appropriate for transmission over network 100. Combiner 112 is coupled to optical transmitter 114. Optical transmitter 114 provides optical signals to optical distribution node 106 over fiber optic link 115. These optical signals are received by

The downstream data path can use any appropriate data communication protocol, including but not limited to, MCNS and DOCSIS.

5 In one embodiment, data on fiber optic links 105 and 115 is carried as base-band digital data using on-off keying. In another embodiment, data on fiber optic links 105 and 115 is carried using modulated carriers. Further, data on fiber optic links 105 and 115 is transmitted using the 100BaseT Ethernet protocol or any other standard or custom protocol.

Advantageously, the return path of network 100 carries digital data from modems 103-1-1, . . . , 103-M-N to head end 102. In one embodiment, modems 103-1-1, . . . , 103-M-N transmit Ethernet packets over network 100. In this embodiment, modems 103-1-1, . . . , 103-M-N include standard Ethernet interfaces 120-1-1, . . . , 120-M-N, respectively. It is understood that in other embodiments, an appropriate interface is used based on the format of the data being transmitted over network 100. Interfaces 120-1-1, . . . , 120-M-N are coupled to media access units 122-1-1, . . . , 122-M-N, respectively. Media access units 122-1-1, . . . , 122-M-N provide physical layer interface for modems 103-1-1, . . . , 103-M-N, respectively.

Optical distribution node 106 includes upstream path circuitry for each coaxial cable link 108-1, . . . , 108-M. Due to the similarity between the circuitry for each coaxial cable link, only the upstream path in optical distribution node 106 for coaxial cable link 108-1 is described here. However, it is understood that the remaining coaxial cable links include similar circuitry in optical distribution node 106.

In one embodiment, modems 103-1-1, . . . , 103-1-N launch digital data on
25 coaxial cable link 108-1 by on-off-keying of one of a selected number of radio
frequency carriers, designated f_1 or f_3 in Figure 1 with digital data in the form of
Ethernet packets. In other embodiments other modulation techniques are used, e.g.,
quadrature phase shift keying (QPSK), quadrature amplitude modulation (QAM), and
other appropriate modulation techniques. Each modem 103-1-1, . . . , 103-1-N uses one
30 of the select number of carriers. It is understood that any appropriate number of carriers

can be used. In one embodiment, each of the select number of carriers falls in the frequency range below the downstream frequency range, e.g., below 42 MHZ. In other embodiments, one or more of the select number of carriers has a frequency above the downstream frequency range, e.g., above 750 MHZ or 850 MHZ. In another

5 embodiment, one or more of the selected carriers falls within the frequency range which is conventionally reserved for downstream transmissions from the head end. In another embodiment, one or more of the carriers is located on other frequencies that are conventionally used for downstream transmission, e.g., a carrier in the frequency range from 50 to 860 MHZ.

10 The upstream path of optical distribution node 106 includes frequency translator 124 that is coupled to coaxial cable link 108-1 through couplers 126 and 128. The output of frequency translator 124 is coupled to coupler 126.

 Frequency translator 124 provides a loopback mechanism to implement a collision detection protocol for the upstream path of network 100 on coaxial cable link

15 108-1. Frequency translator 124 translates modulated carriers, e.g., f_1 and f_3 , to other frequencies, e.g., f_2 and f_4 , respectively. Essentially, frequency translator 124 provides aggregate data received from all modems 103-1-1, . . . , 103-1-N on coaxial cable link 108-1 back to modems 103-1-1, . . . , 103-1-N. Each modem 103-1-1, . . . , 103-1-N compares its transmitted data with the aggregate data to determine whether its data was

20 received at optical distribution node 106 without collision with other data or without corruption from ingress noise.

 When a modem detects a collision, the modem provides a collision detection signal on another carrier. The modem further waits a randomly selected period of time to attempt retransmission. Advantageously, this process allows network 100 to transmit

25 digital, upstream signals in the conventional upstream band despite ingress and other interference since interference looks like a collision to network 100 and data affected by the interference is automatically retransmitted.

 Optical distribution node 106 also includes coupler 130 that provides data to media access units 132 and 134. Each media access unit 132 and 134 is provided to

30 handle data for each modulated carrier used by modems 103-1-1, . . . , 103-M-N on

coaxial cable link 108-1. Media access units 132 and 134 are coupled to data concentrator 136 through interface circuits 138 and 140, respectively. Interface circuits 138 and 140 determine whether the data received from coaxial cable link 108-1 is valid data, e.g., interface circuits 138 and 140 determine whether a collision was detected on coaxial cable link 108-1. Data concentrator 136 concentrates data from coaxial cable links 108-1, . . . , 108-M for transmission upstream to head end 102 by laser 142. In one embodiment, laser 142 transmits the upstream, digital data with base-band on-off-keying using 100BASET data format. At head end 102, the data is switched or routed into a data network, e.g., a standard-based or proprietary, private or public network.

10 In operation, digital data is transmitted from modems 103-1-1, . . . , 103-M-N over network 100 to head end 102. For example, digital data originating at modem 103-1-1 is provided to coaxial cable 108-1 on a modulated carrier. Frequency translator 124 translates the frequency of the modulated carrier and retransmits the data back to modem 103-1-1 with aggregate data from all modems on coaxial link 108-1. Modem 15 103-1-1 checks for collisions and if any, transmits a collision detect signal on a separate carrier and then waits a random amount of time and retransmits the data.

In the absence of a collision, the data is passed to data concentrator 136 and concentrated with data from other coaxial links. This data is passed to head end 102 over optical fiber link 105 by transmitter 142. At head end 102, the data is routed or 20 switched to other networks.

Node 106 of Figure 1 advantageously combines CSMA/CD error detection through frequency translation (“frequency turn-around”) and data concentration. This combination of functionality is shown in Figure 3. Frequency turn-around is performed at the physical layer as indicated next to blocks 302 and 304. Further, routing 25 functionality, e.g., concentration and switching, is provided at the network layer as indicated by blocks 306 and 308. In this manner, the frequency turn-around scheme does not require modulation or demodulation processes and is kept transparent to the hardware at node 106.

Conclusion

A hybrid fiber/coax network has been described with a digital return path. Essentially, digital data is modulated on one or more carriers within the conventional upstream bandwidth by modems and provided to an optical distribution node. A

5 collision detection process is used by looping back aggregate data to the modems on a common coaxial cable link. The data from a number of coaxial cable links are concentrated and transmitted as digital data over a fiber optic connection to a head end or hub.

Although specific embodiments have been illustrated and described herein, it
10 will be appreciated by those of ordinary skill in the art that any arrangement which is calculated to achieve the same purpose may be substituted for the specific embodiment shown. This application is intended to cover any adaptations or variations of the present invention. For example, data can be transmitted in formats other than standard Ethernet formats. Further, any appropriate number of carrier frequencies can be used to carry
15 digital data to the optical distribution nodes. Also, a part of the upstream data can be transmitted on carriers that are located above 850 MHZ in the frequency spectrum. This allows the upstream data path to carry more data than the conventional upstream band. Further, it is understood that a portion of the upstream path can be carried on the conventional downstream frequencies, e.g., between 42 and 850 MHZ, if the spectrum
20 is not allocated for downstream communication. An optical distribution node can also support as few as one coaxial cable link. Further, modulation formats other than on-off keying can be used, including, but not limited to quadrature phase-shift keying (QPSK) and quadrature amplitude modulation (QAM). In one embodiment, frequency turn-around at node 106 is accomplished according to ANSI/IEEE standard 802.3 (1996)
25 (the "10BROAD36 standard"). Further, it is understood that a frequency translator can be coupled to one or more coaxial cable links.

What is claimed is:

1. A hybrid fiber/coax network, comprising:
 - a head end;
 - 5 at least one optical distribution node coupled to the head end over at least one fiber optic link;
 - at least one coaxial cable link, coupled to the at least one optical distribution node, that receives upstream, digital data from a plurality of modems; and
 - wherein the at least one optical distribution node has a digital return path that
 - 10 includes:
 - a laser transmitter coupled to the fiber optic link that transmits the upstream, digital data to the head end;
 - a data concentrator coupled to provide the upstream, digital data to the laser; and
 - 15 for the at least one coaxial cable link,
 - a frequency translator that receives and translates the upstream, digital data from the plurality of modems to a different carrier frequency and retransmits the signal to the plurality of modems for collision detection; and
 - 20 a data interface coupled between frequency translator and the data concentrator that determines whether the upstream, digital data is valid.
2. The network of claim 1, wherein at least a portion of the upstream, digital data is
- 25 transmitted over the at least one coaxial cable link on modulated carriers below 42 MHZ.
3. The network of claim 1, wherein the modulated carriers are modulated with the upstream, digital data using one of on-off-keying, quadrature phase-shift keying and
- 30 quadrature amplitude modulation.

4. The network of claim 1, wherein the upstream, digital data is carried on one of at least two modulated carriers.

5. The network of claim 1, wherein the plurality of modems transmit collision detection signals on a different modulated carrier when a collision is detected based on signals from the frequency translator.

6. The network of claim 1, wherein the upstream, digital data comprises Ethernet packets.

10

7. The network of claim 2, wherein at least another portion of the upstream, digital data is transmitted over the plurality of coaxial cable links on modulated carriers above a cut-off frequency for downstream transmissions.

15 8. The network of claim 1, wherein the laser transmitter transmits the upstream, digital data as one of base-band and modulated carrier transmission.

9. The network of claim 1, and further including a receiver circuit coupled to the fiber optic link and the at least one coaxial cable link that receives downstream optical signals and converts the signals to electrical signals for transmission over the at least one coaxial cable link.

10. A hybrid fiber-coax network, comprising:
a head end;
25 at least one optical distribution node coupled to the head end over at least one fiber optic link;
at least one coaxial cable link, coupled to the at least one optical distribution node, that receives upstream, digital data from a plurality of modems;

wherein at least a portion of the upstream, digital data is transmitted over the at least one coaxial cable link on at least one modulated carrier below a frequency range for downstream transmission; and

wherein the at least one optical distribution node includes circuitry for detecting
5 collisions on the at least one coaxial cable link.

11. The network of claim 10, wherein the modulated carriers are modulated with the upstream, digital data using one of on-off-keying, quadrature phase-shift keying and quadrature amplitude modulation.

10

12. The network of claim 10, wherein the upstream, digital data is carried on one of at least two modulated carriers.

13. The network of claim 10, wherein the plurality of modems transmit collision
15 detection signals on a different modulated carrier when a collision is detected based on signals from the frequency translator.

14. The network of claim 10, wherein the upstream, digital data comprises Ethernet
packets.

20

15. The network of claim 10, wherein at least another portion of the upstream, digital data is transmitted over the at least one coaxial cable link on modulated carriers above a cut-off frequency for the downstream transmissions.

25 16. The network of claim 10, wherein the at least one optical distribution node transmits the upstream, digital data as one of base-band and modulated carrier transmission.

17. The network of claim 10, and further including a receiver circuit coupled to the
30 fiber optic link and the at least one coaxial cable link that receives downstream optical

signals and converts the signals to electrical signals for transmission over the at least one coaxial cable link.

18. An optical distribution node for an hybrid fiber/coax network, the optical
5 distribution node comprising:
a laser transmitter coupleable to a fiber optic link that transmits upstream, digital data to a head end of the network;
a data concentrator coupled to provide the upstream, digital data to the laser; and
for at least one coaxial cable link of the network coupleable to the optical
10 distribution node,
a frequency translator that receives the upstream, digital data modulated on a first carrier frequency from a plurality of modems and translates the upstream, digital data to a different carrier and retransmits the upstream, digital data to the plurality of modems
15 for collision detection; and
a data interface coupled between the at least one coaxial cable link and the data concentrator that determines whether the upstream data is valid.
- 20 19. The node of claim 18, and further including at least one media access unit coupled to the at least one coaxial cable link and the data concentrator.
20. The node of claim 18, wherein the upstream, digital data comprises Ethernet packets.
- 25 21. The node of claim 18, wherein the laser transmitter transmits the upstream, digital data as one of base-band and modulated carrier transmission.
22. The node of claim 18, wherein the frequency translator also receives upstream,
30 digital data on at least one additional carrier.

23. The node of claim 18, wherein the frequency translator receives the upstream, digital data modulated on a first carrier with a frequency that is below the frequency range for downstream transmissions.
- 5 24. A method for processing data in a return path of a hybrid fiber/coax network, the method comprising:
 - receiving, on a first coaxial cable, upstream, digital data modulated on a first carrier;
 - translating the frequency of the first carrier to a second frequency;
 - 10 retransmitting the upstream, digital data modulated on the carrier with the second frequency;
 - checking for collision detection signals based on the retransmitted upstream, digital data;
 - concentrating the upstream, digital data with upstream, digital data from other
 - 15 coaxial cables; and
 - transmitting the concentrated, upstream, digital data to the head end.
- 20 25. The method of claim 24, wherein receiving digital data comprises receiving digital data on a first carrier below a frequency range for downstream transmission.
26. The method of claim 24, wherein translating the frequency of the first carrier comprises translating the frequency of the first carrier to a second frequency below the frequency used for downstream transmission.
- 25 27. The method of claim 24, wherein checking for collision detection signals comprises monitoring a third frequency for collision detection signals.
28. The method of claim 24, wherein transmitting the concentrated, upstream, digital data comprises transmitting base-band signals as one of base-band and
- 30 modulated carrier transmission.

29. The method of claim 24, wherein receiving, on a coaxial cable, upstream, digital data comprises receiving Ethernet packets on a modulated carrier.

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Abstract of the Disclosure

An optical distribution node for an hybrid fiber/coax network is provided. The optical distribution node includes a laser transmitter coupleable to a fiber optic link that transmits upstream, digital data to a head end of the network. The node also includes a data concentrator coupled to provide the upstream, digital data to the laser. For at least one coaxial cable link of the network coupleable to the optical distribution node, the node also includes a frequency translator that receives the upstream, digital data modulated on a first carrier frequency and retransmits the upstream, digital data to the plurality of modems for collision detection. The node also includes a data interface coupled between the at least one coaxial cable link and the data concentrator that determines whether the upstream data is valid.

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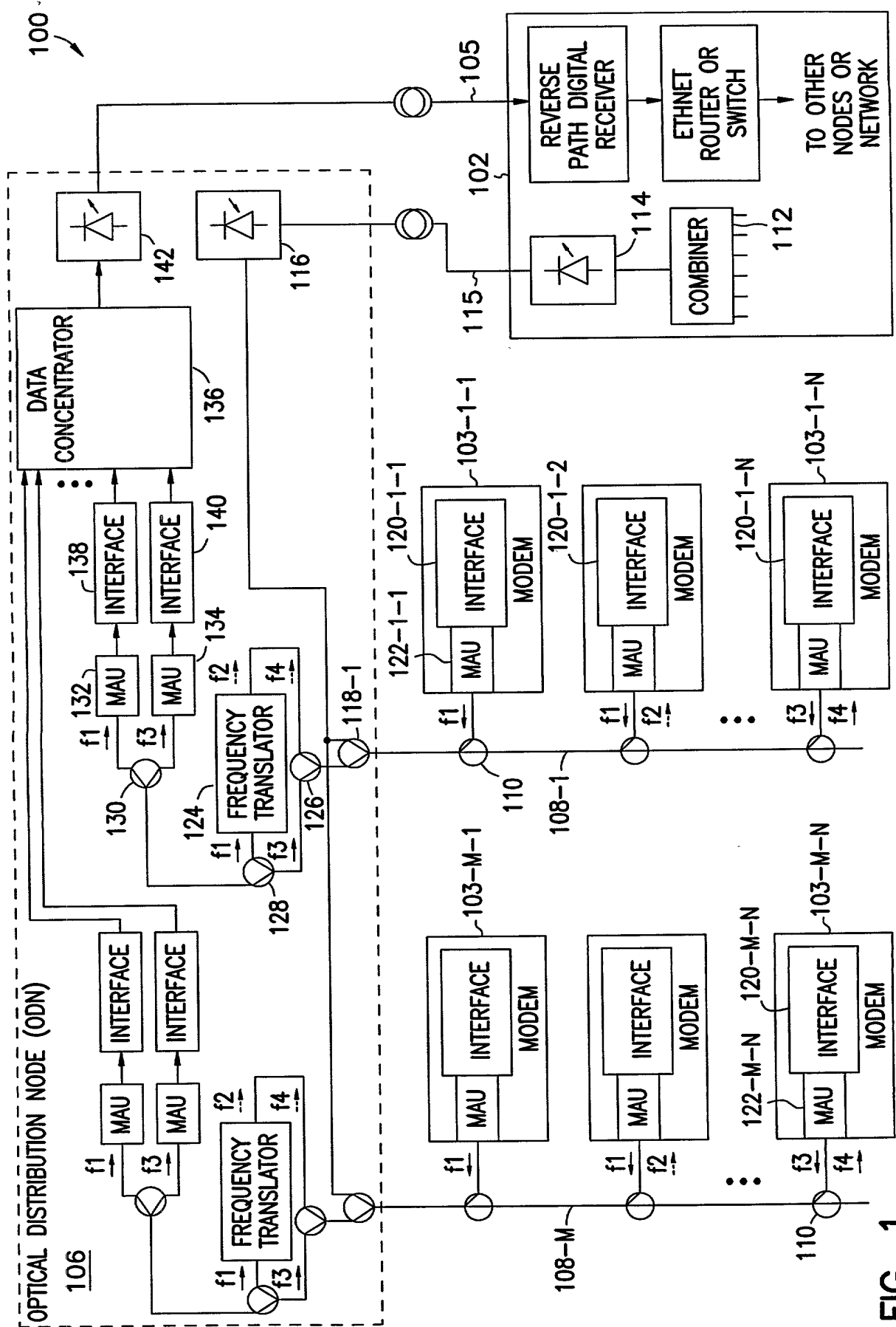


FIG. 1

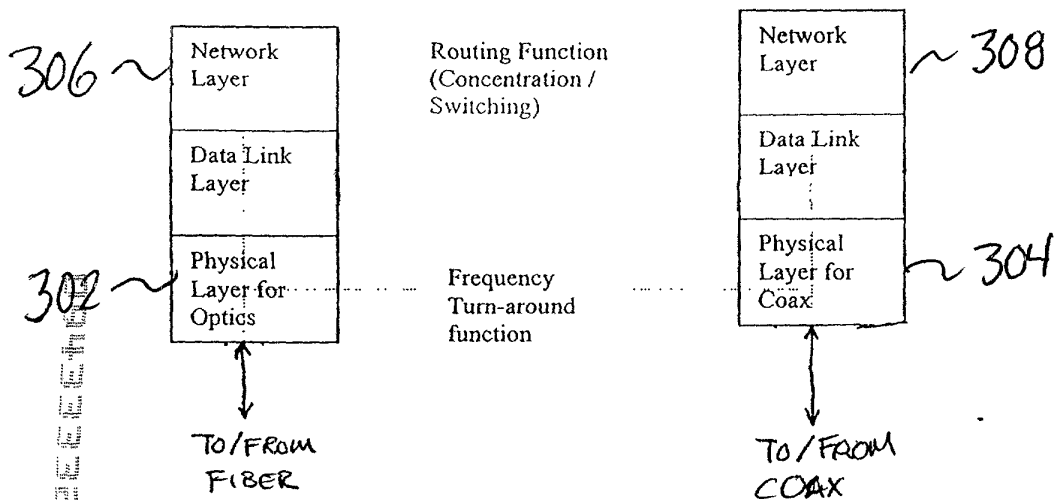


FIG. 2

SCHWEGMAN, LUNDBERG, WOESSNER & KLUTH, P.A.

United States Patent Application

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: **DIGITAL RETURN PATH FOR HYBRID FIBER/COAX NETWORK**.

The specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. § 1.56 (attached hereto). I also acknowledge my duty to disclose all information known to be material to patentability which became available between a filing date of a prior application and the national or PCT international filing date in the event this is a Continuation-In-Part application in accordance with 37 C.F.R. § 1.63(e).

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 120 or 365(c) of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. § 1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

No such claim for priority is being made at this time.

Attorney Docket No.: 500 722US1

No. not assigned

Date: not assigned

Page 2 of 3

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Fogg, David N.	Reg. No. 35,138	Malen, Peter L.	Reg. No. P-44,894	Viksnins, Ann S.	Reg. No. 37,748
Fordebacher, Paul J.	Reg. No. 42,546	Mates, Robert E.	Reg. No. 35,271	Woessner, Warren D.	Reg. No. 30,440

I hereby authorize them to act and rely on instructions from and communicate directly with the person/assignee/attorney/firm/organization/who/which first sends/sent this case to them and by whom/which I hereby declare that I have consented after full disclosure to be represented unless/until I instruct Schwegman, Lundberg, Woessner & Kluth, P.A. to the contrary.

Please direct all correspondence in this case to Schwegman, Lundberg, Woessner & Kluth, P.A. at the address indicated below:

P.O. Box 2938, Minneapolis, MN 55402

Telephone No. (612)373-6900

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of sole inventor:

John E. Donohue

Citizenship:

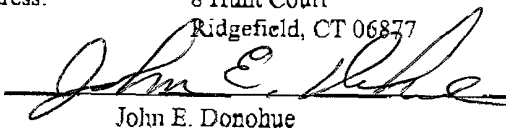
United States of America

Residence: Ridgefield, CT

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Signature:


John E. Donohue

Date:

10/29/99

Full Name of inventor:

Citizenship:

Residence:

Post Office Address:

Signature:

Date:

Attorney Docket No.: 500 722US1

Serial No. not assigned

Date: not assigned

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§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) prior art cited in search reports of a foreign patent office in a counterpart application, and
- (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

- (1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or
- (2) It refutes, or is inconsistent with, a position the applicant takes in:
 - (i) Opposing an argument of unpatentability relied on by the Office, or
 - (ii) Asserting an argument of patentability

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

- (1) Each inventor named in the application.
- (2) Each attorney or agent who prepares or prosecutes the application; and
- (3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.